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Kwon et al.

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(54) **DISTRIBUTED BRAGG REFLECTOR TUNABLE LASER DIODE**

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(58) **Field of Classification Search**
CPC H01S 5/125; H01S 5/0612; H01S 5/1221; H01S 5/20; H01S 5/06256; G02B 6/12; G02B 2006/12107
See application file for complete search history.

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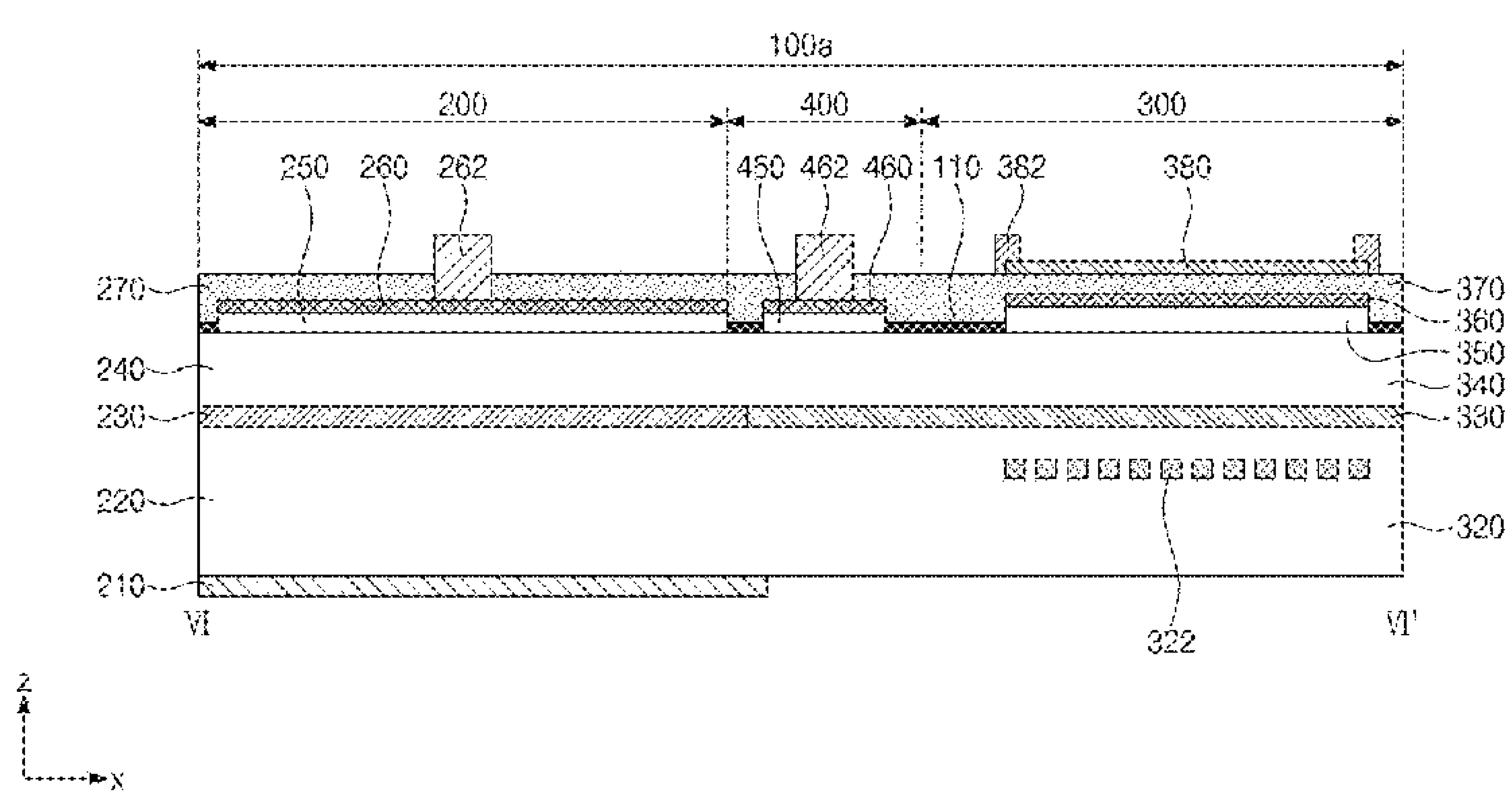
(57) **ABSTRACT**

Provided is a distributed Bragg reflector tunable laser diode including a substrate provided with a gain section having an active waveguide from which a gain of laser light is obtained and a distributed reflector section having a passive waveguide connected to the active waveguide, wherein the distributed reflector section includes gratings disposed on or under the passive waveguide, a current injection electrode disposed on the passive waveguide and configured to provide a current into the passive waveguide to electrically tune a wavelength of the laser light, and a heater electrode disposed on the current injection electrode and configured to heat the passive waveguide to thermally tune the wavelength
(Continued)



of the laser light, wherein the gratings, the current injection electrode, and the heater electrode vertically overlap each other.

14 Claims, 9 Drawing Sheets

(51) **Int. Cl.**
H01S 5/20 (2006.01)
H01S 5/12 (2006.01)
H01S 5/06 (2006.01)
G02B 6/12 (2006.01)

(52) **U.S. Cl.**
CPC ***H01S 5/06256*** (2013.01); ***H01S 5/1221*** (2013.01); ***H01S 5/20*** (2013.01); *G02B 2006/12107* (2013.01)

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FIG. 1

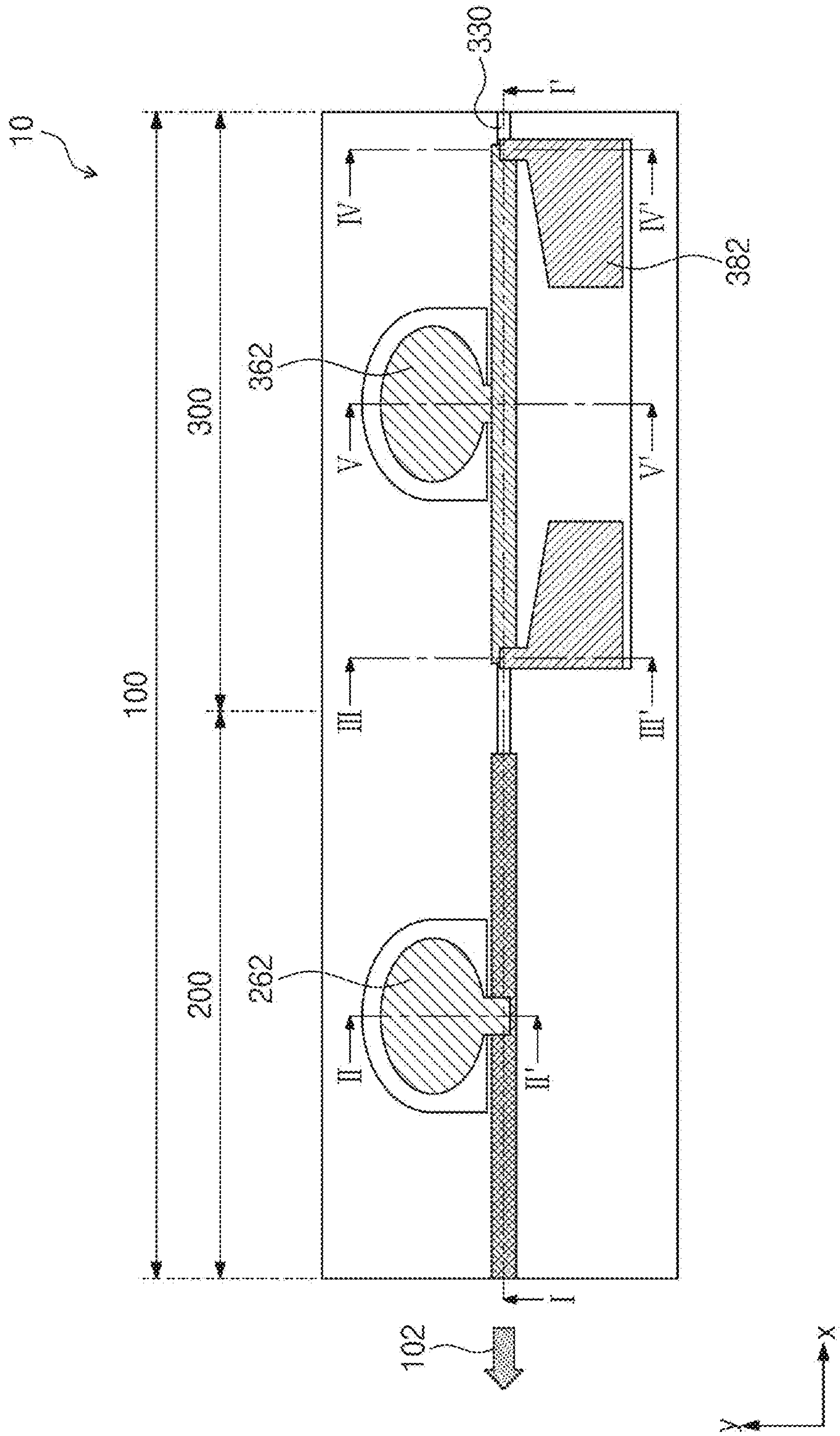


FIG. 2

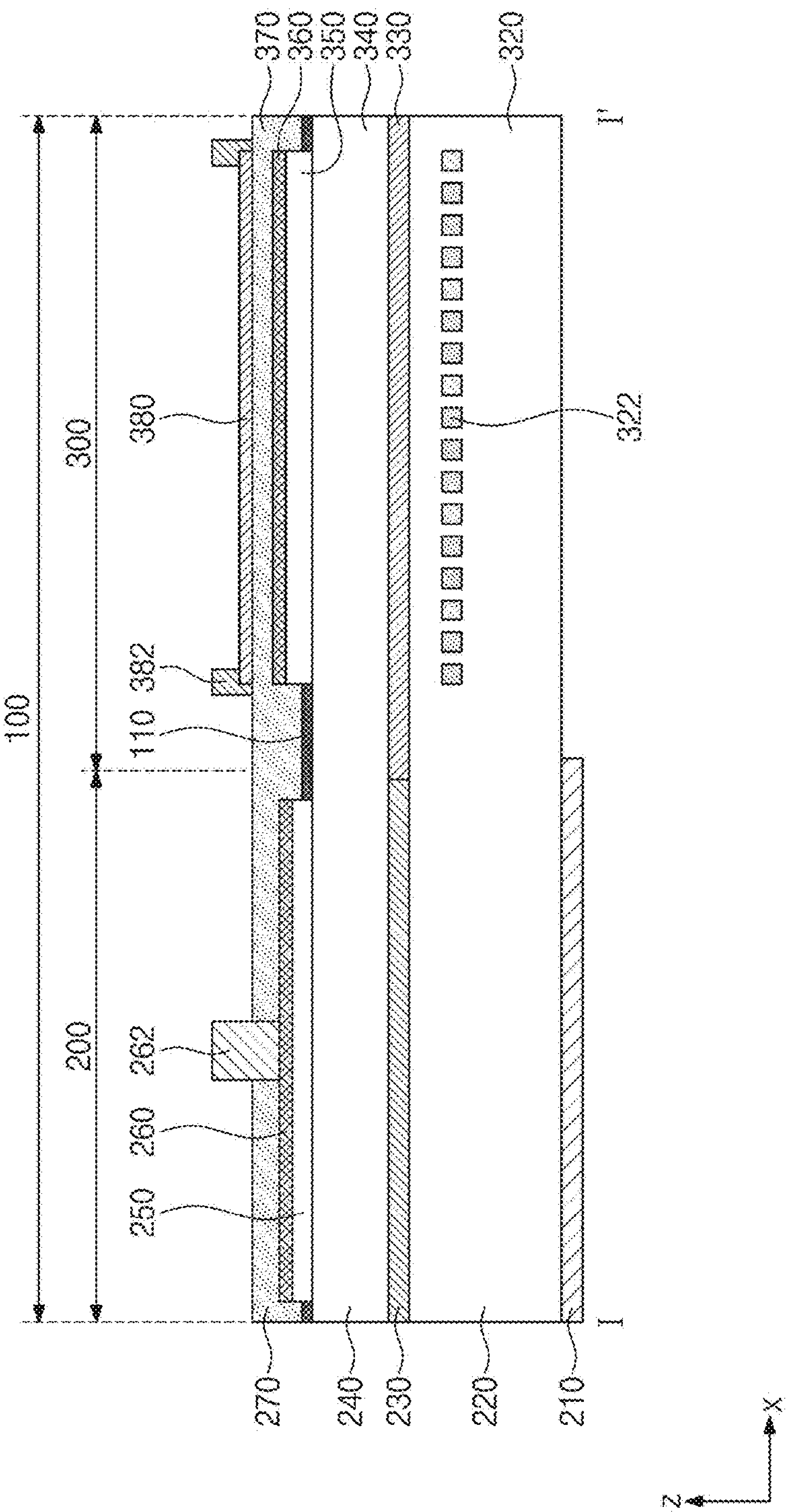

370
360
350
340
330
320
322
380
300
382
110
100
200
262
260
250
270
240
230
220
210
I
I'
X
Z

FIG. 3

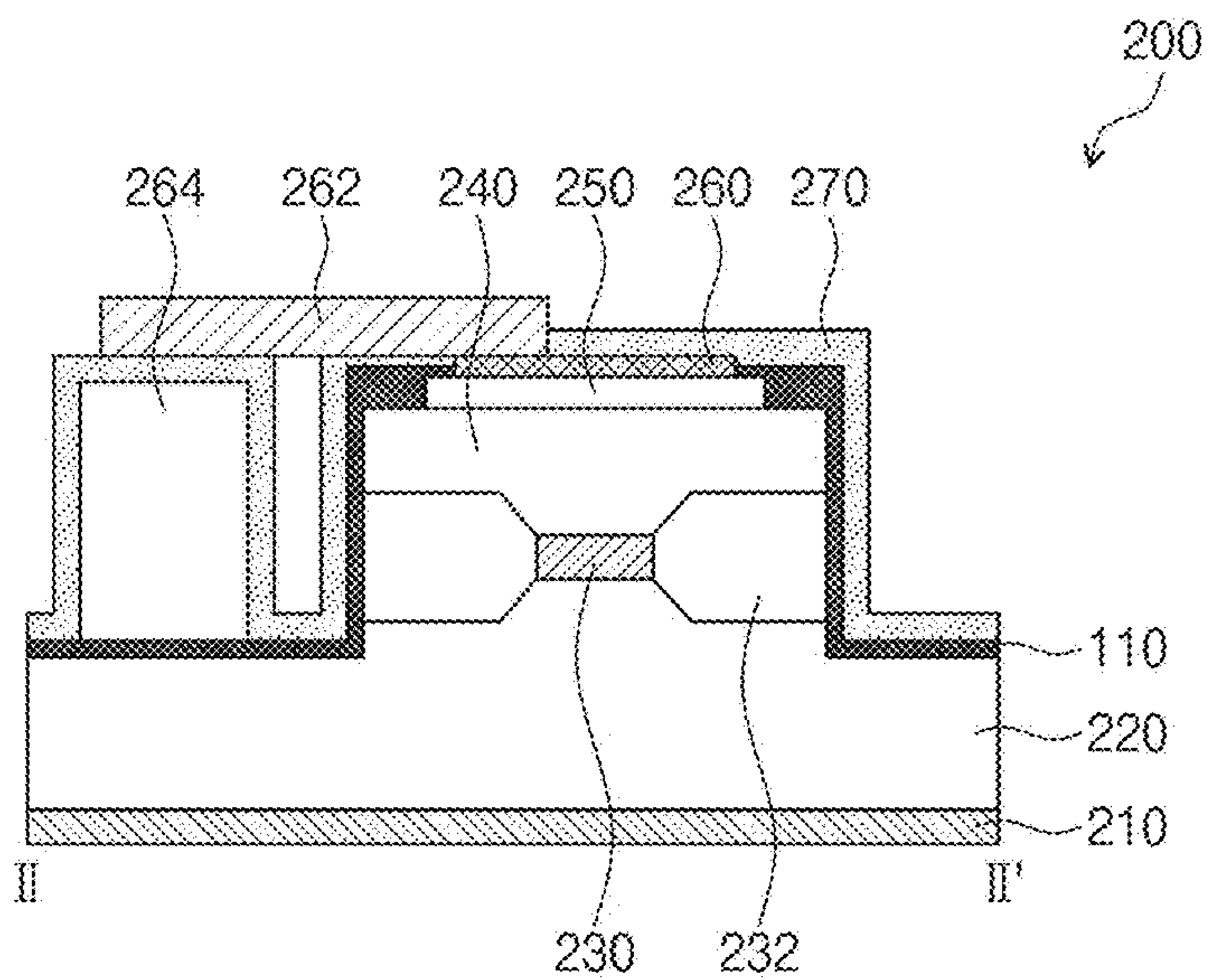

200
264
262
240
250
260
270
110
220
210
II
II'
230
232

FIG. 4

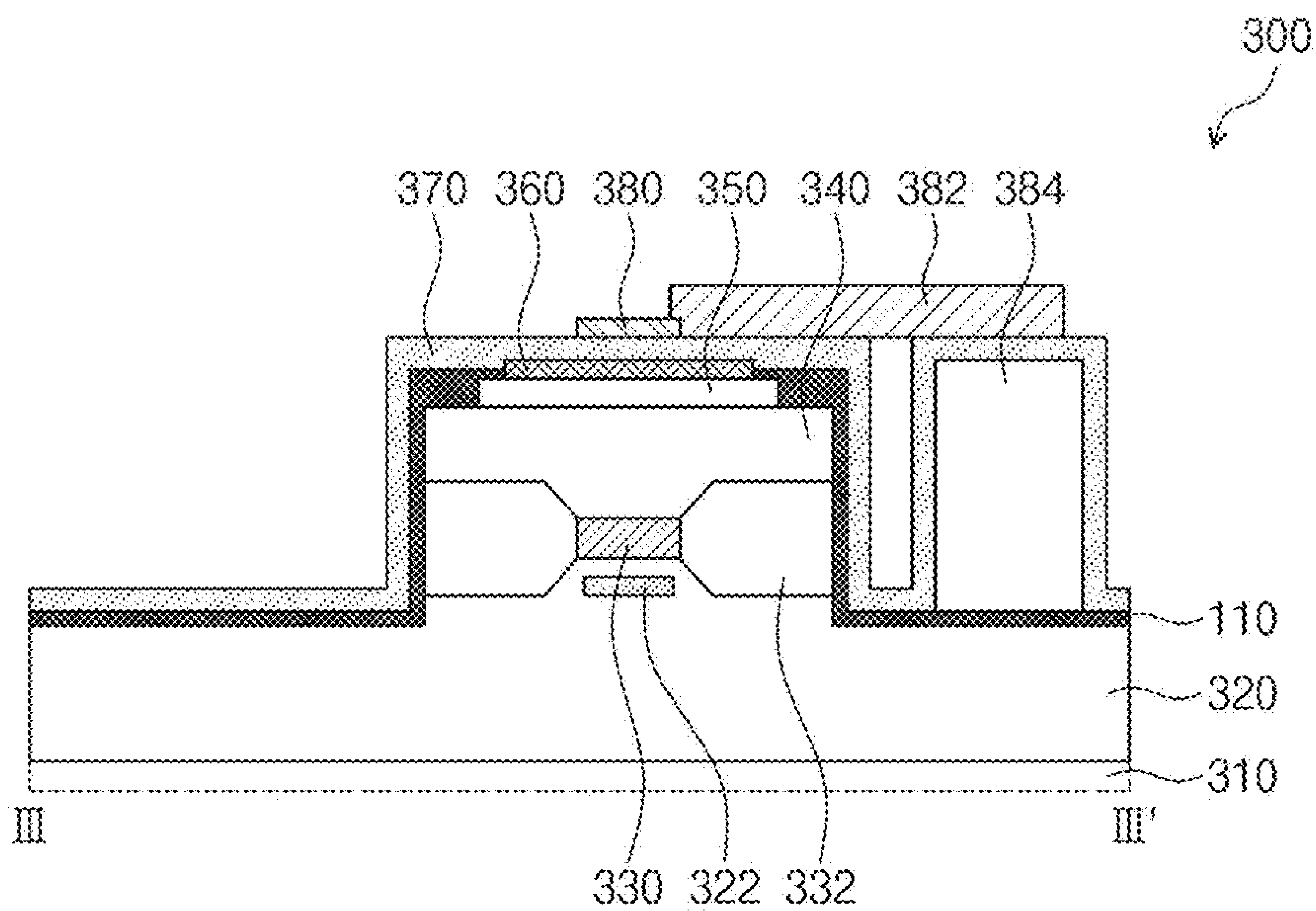

300
370
360
380
350
340
382
384
110
320
310
III
III'
330
322
332

FIG. 5

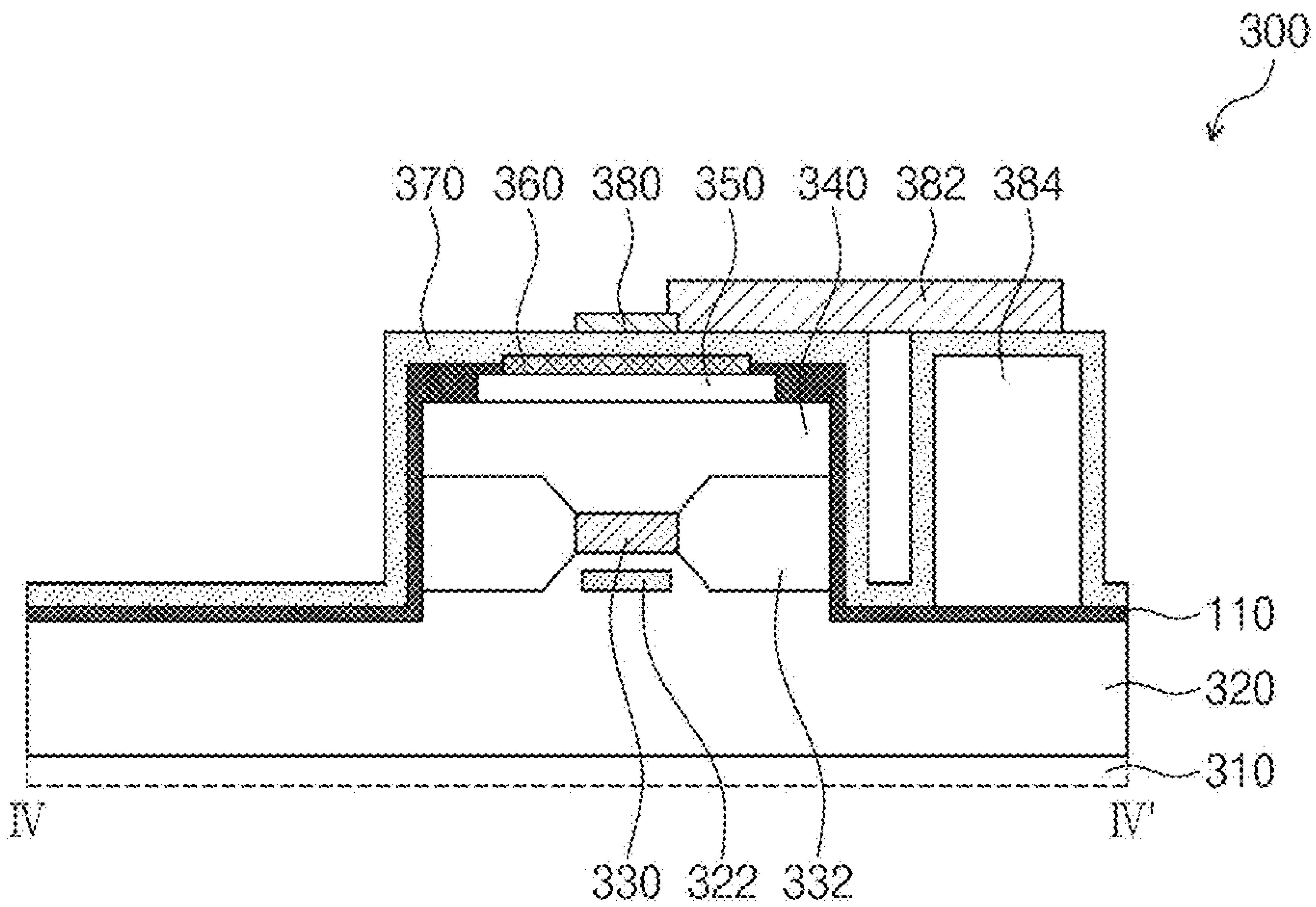

300
370
360
380
350
340
382
384
110
320
310
IV
IV'
330
322
332

FIG. 6

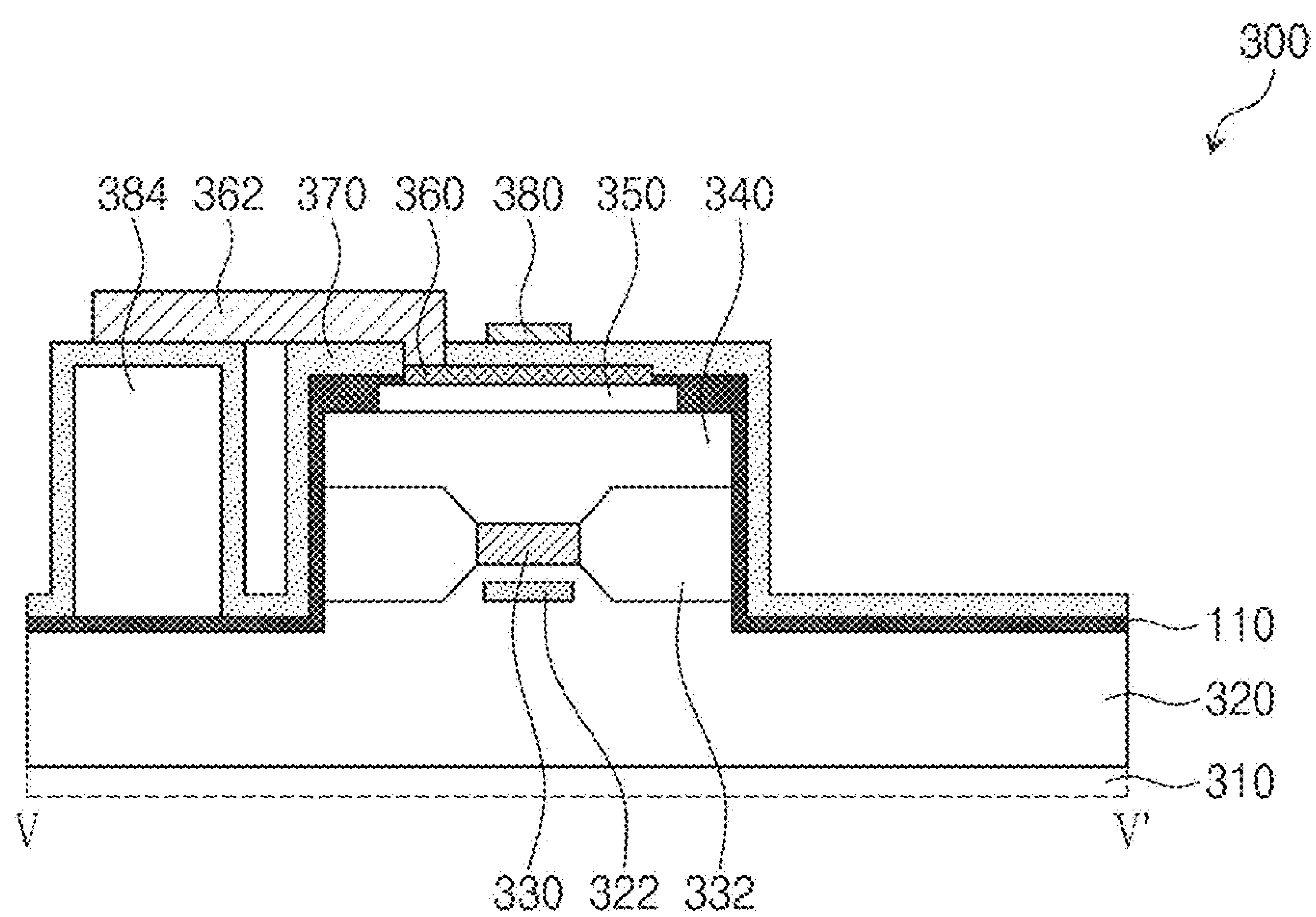

300
384
362
370
360
380
350
340
110
320
310
V
V'
330
322
332

FIG. 7

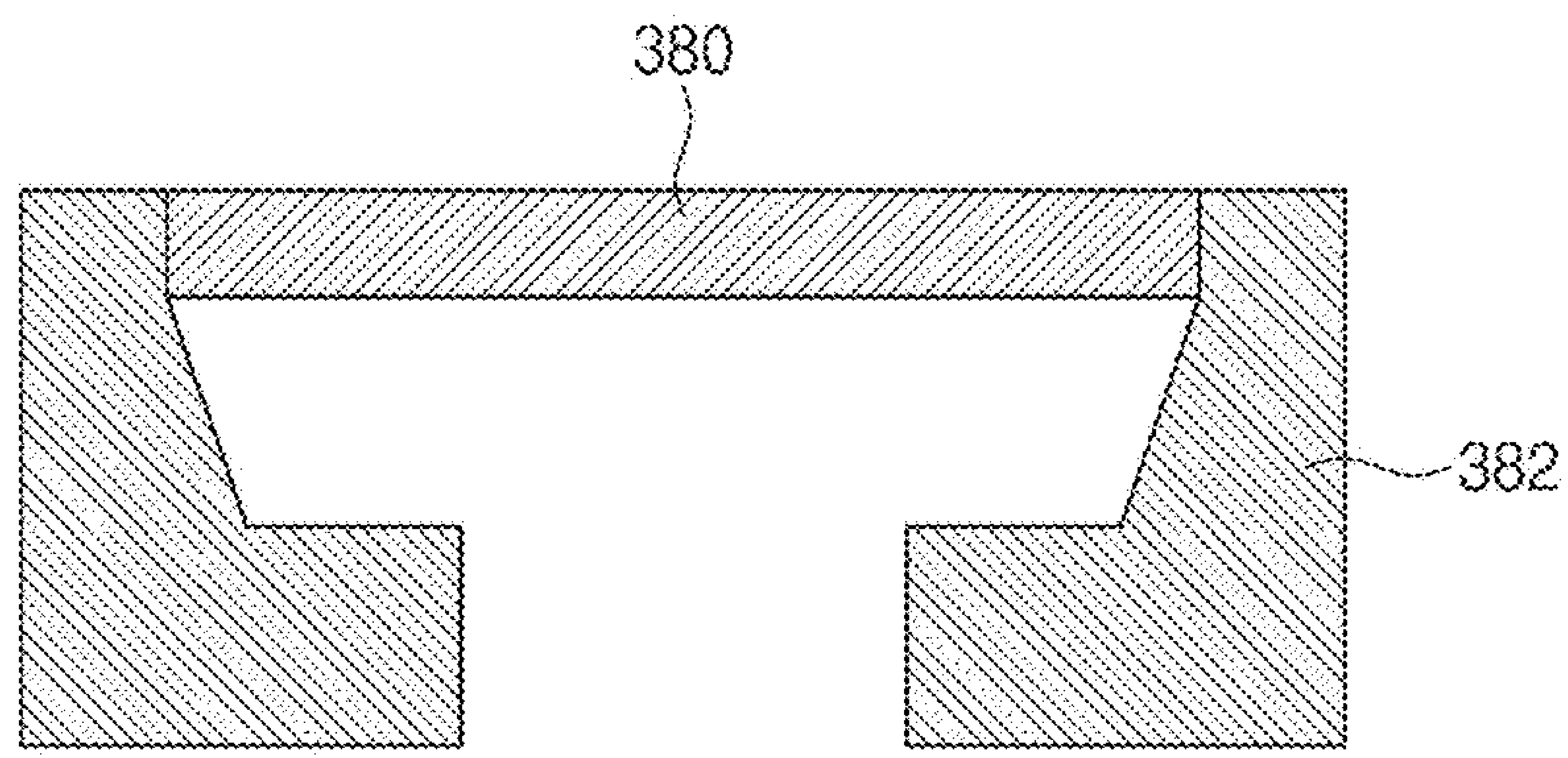


FIG. 8

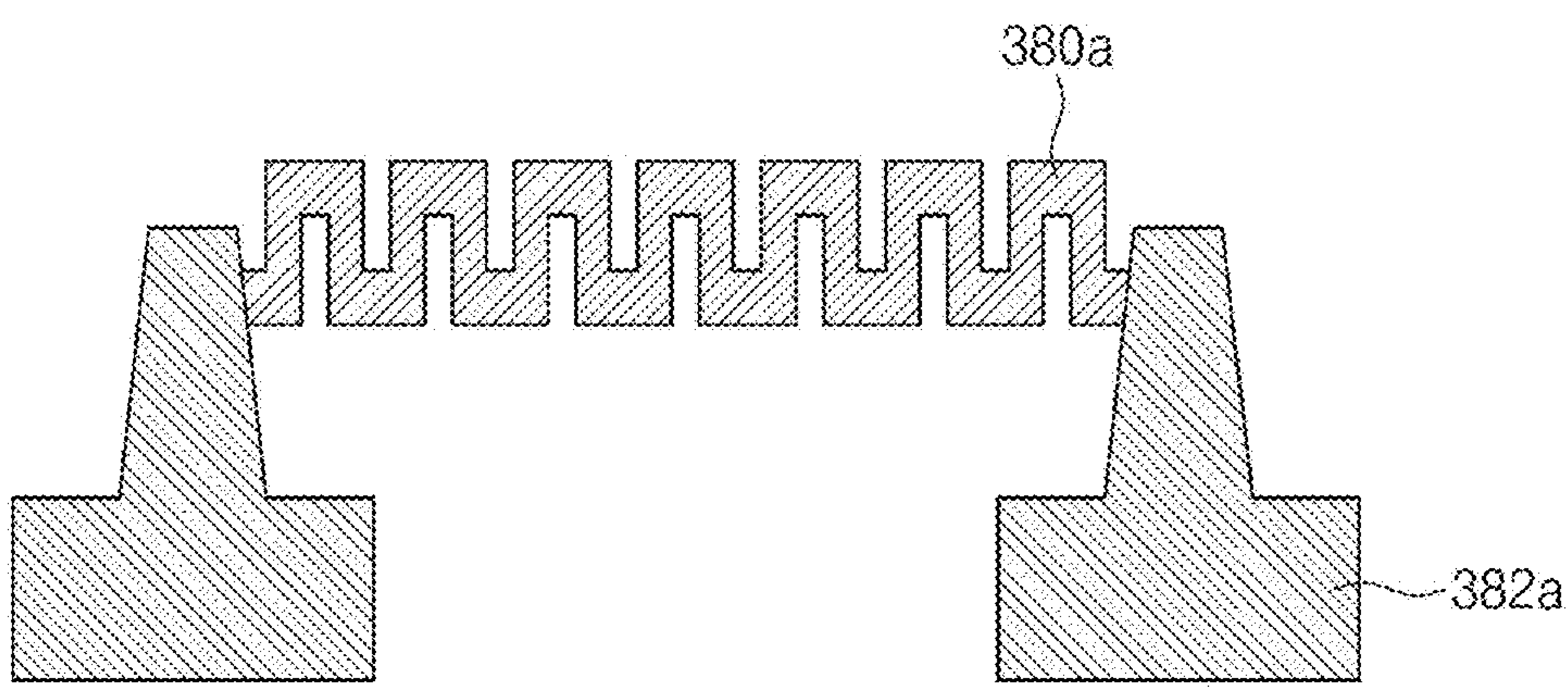


FIG. 9

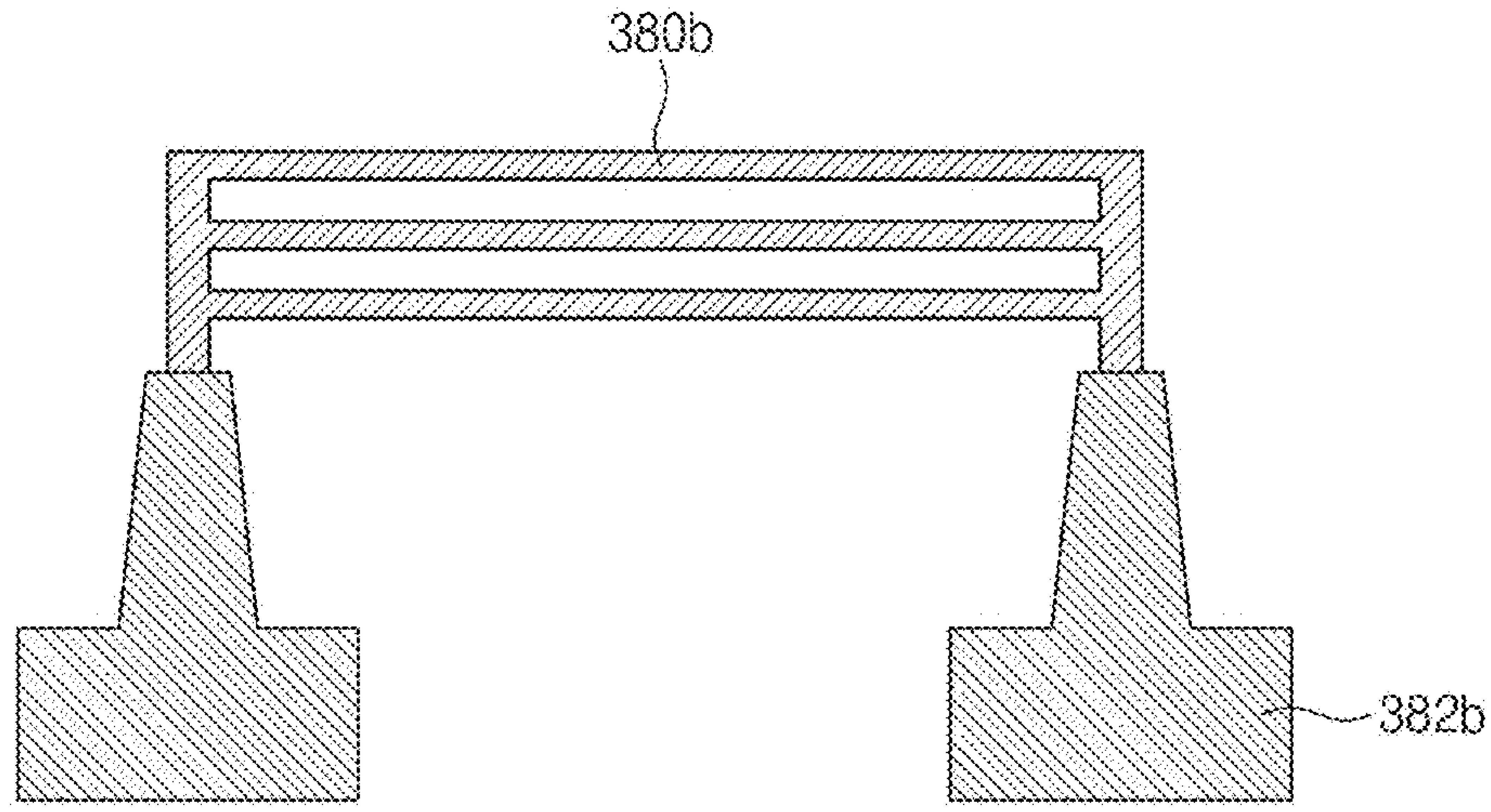


FIG. 10

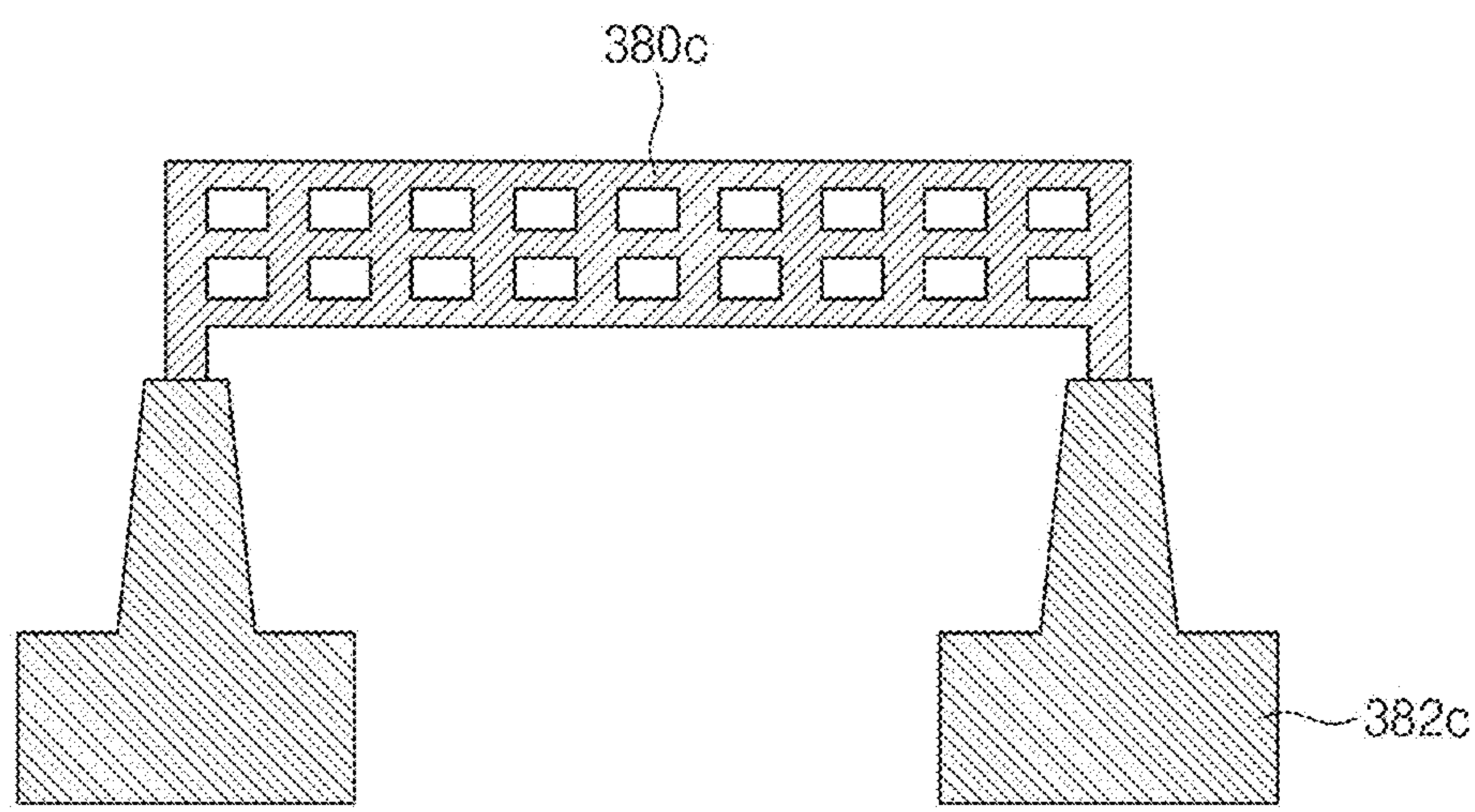


FIG. 11

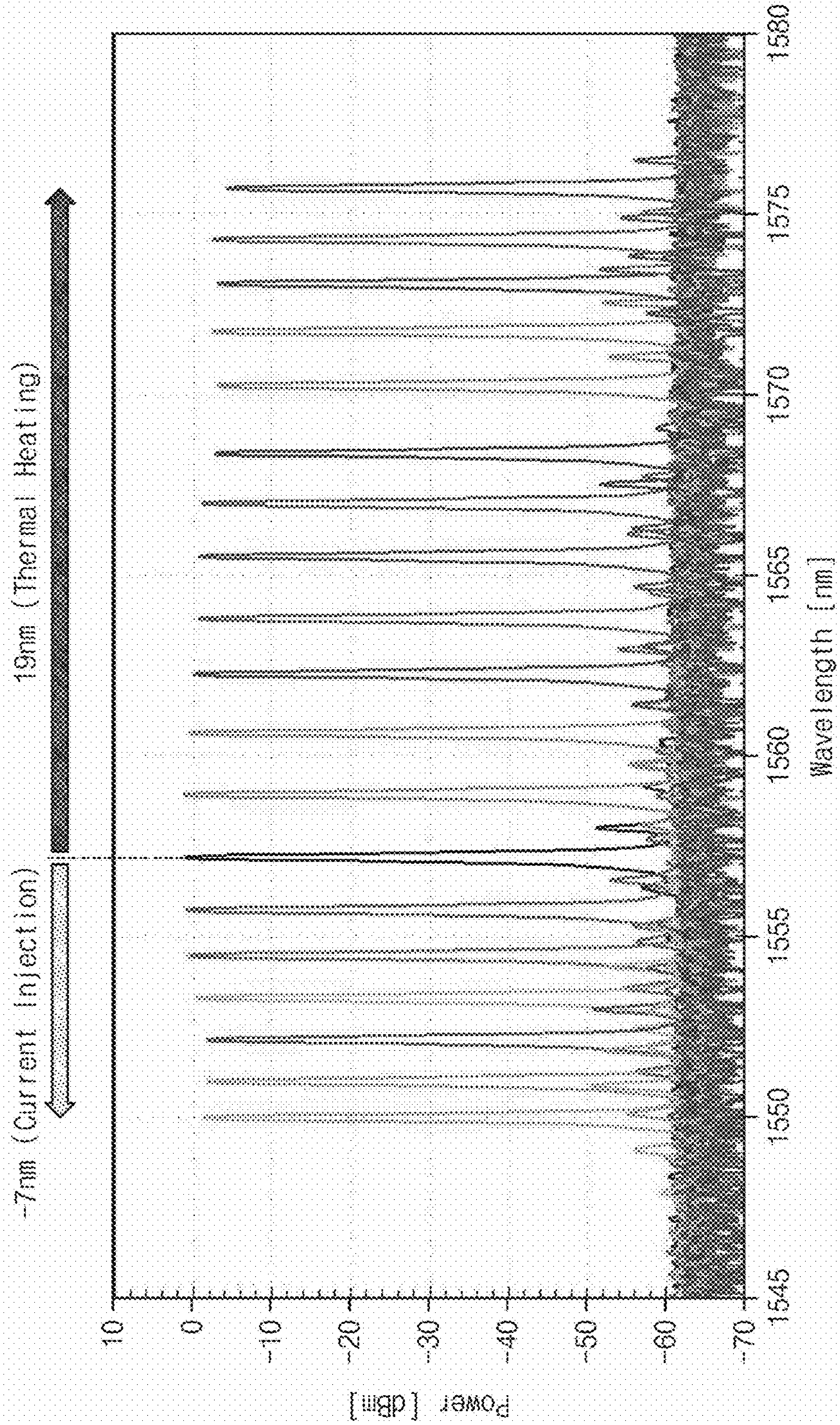

-7nm (Current Injection)
19nm (Thermal Heating)
Power [dBm]
10
0
-10
-20
-30
-40
-50
-60
-70
1545
1550
1555
1560
1565
1570
1575
1580
Wavelength [nm]

FIG. 12

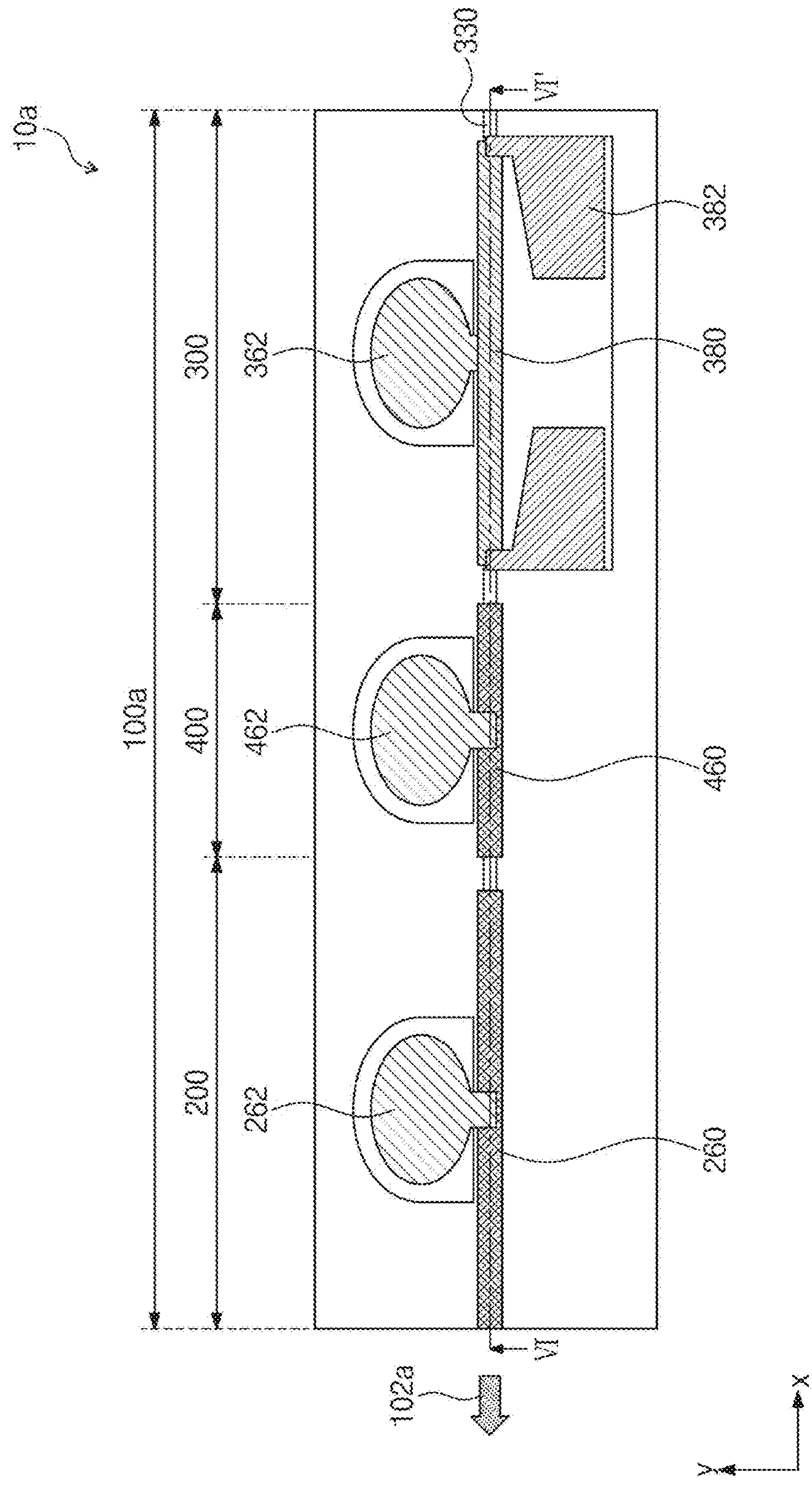
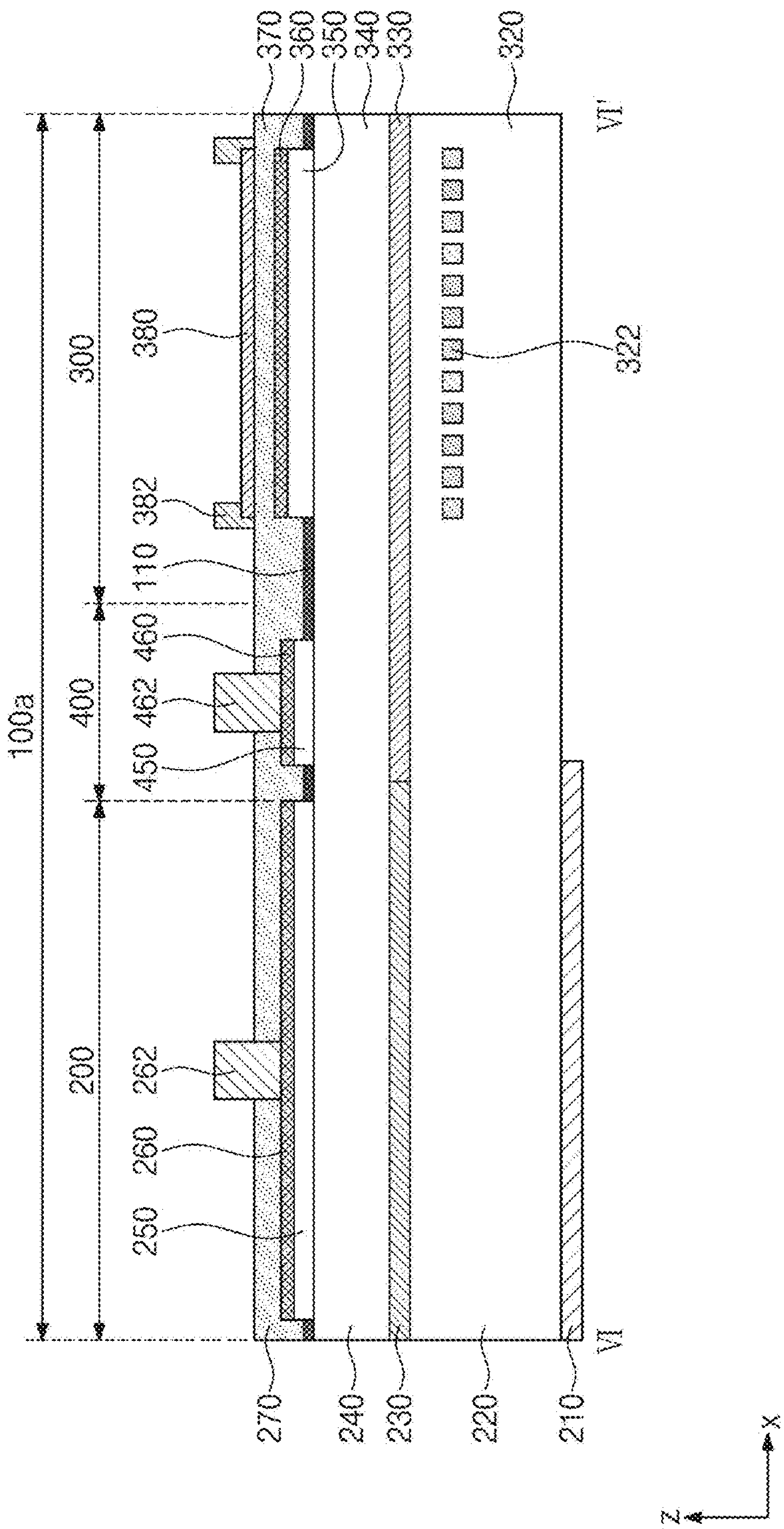

10a
330
VI'
362
362
380
300
100a
400
462
460
200
262
260
VI
102a
X
Y

FIG. 13


370
360
350
340
330
320
VI'
100a
300
380
382
110
400
460
462
450
322
200
262
260
250
270
240
230
220
210
VI
z
x

DISTRIBUTED BRAGG REFLECTOR TUNABLE LASER DIODE

CROSS-REFERENCE TO RELATED APPLICATIONS

This U.S. non-provisional patent application claims priority under 35 U.S.C. § 119 of Korean Patent Application No. 10-2017-0009346, filed on Jan. 19, 2017, the entire contents of which are hereby incorporated by reference.

BACKGROUND

The present disclosure herein relates to a laser device, and more particularly, to a distributed Bragg reflector (DBR) tunable laser diode in which a wavelength of a laser light is electrically and thermally tunable.

A typical DBR tunable laser diode may be a longitudinal single-mode light source and a wavelength tunable laser. The typical DBR tunable laser diode may include a gain section and a DBR section. The gain section, a phase section and the DBR section may be monolithically integrated in a waveguide type in a semiconductor substrate.

SUMMARY

An exemplary embodiment of the inventive concept disclosure provides a distributed Bragg reflector tunable laser diode in which a wavelength of a laser light is efficiently tunable.

An exemplary embodiment of the inventive concept provides a distributed Bragg reflector tunable laser diode. The laser diode comprises a substrate including: a gain section which has an active waveguide to get a gain of laser light; and a distributed reflector section which has a passive waveguide connected to the active waveguide. Here the distributed reflector section may include: gratings disposed on or under the passive waveguide; a current injection electrode disposed on the passive waveguide and configured to provide a current into the passive waveguide to electrically tune a wavelength of the laser light; and a heater electrode disposed on the current injection electrode and configured to heat the passive waveguide to thermally tune the wavelength of the laser light. The gratings, the current injection electrode, and the heater electrode may vertically overlap each other.

In an embodiment, the gain section may further include: a first lower electrode under the active waveguide; a first lower clad between the first lower electrode and the active waveguide; a first upper clad disposed on the active waveguide; and a first upper electrode disposed on the first upper clad.

In an embodiment, the distributed reflector section may further include: a second lower clad connected to the first lower clad and surrounding the gratings; and a second upper clad connected to the first upper clad and disposed on the passive waveguide.

In an embodiment, the distributed reflector section may further include a second lower electrode connected to the first lower electrode and disposed under the second lower clad.

In an embodiment, the gain section may further include a first contact electrode between the first upper clad and the first upper electrode. The distributed reflector section may further include a second contact electrode between the second upper clad and the current injection electrode.

In an embodiment, the distributed reflector section may further include an insulation layer between the current injection electrode and the heater electrode. The insulation layer may be disposed between the first and second contact electrodes.

In an embodiment, the distributed reflector section may further include: first and second pads connected to the current injection electrode and the heater electrode; and first and second columns disposed between the first and second pads and between the first and second lower clads.

In an embodiment, the first and second columns may include benzocyclobutene.

In an embodiment, the substrate may further include a phase section between the gain section and the distributed reflector section.

In an embodiment, the heater electrode may have a straight line shape, an uneven shape, a comb shape, or a mesh shape.

In an embodiment, the substrate may include InP.

In an embodiment, the current may reduce a wavelength of the laser light.

In an embodiment, the wavelength of the laser light may be increased by heating the passive waveguide.

In an embodiment of the inventive concept, a distributed Bragg reflector tunable laser diode includes: a lower electrode; a lower clad disposed on the lower electrode; gratings disposed in one side of the lower clad; a waveguide including a passive waveguide on the one side of the lower clad and an active waveguide on another side of the lower clad, the active waveguide generating laser light; an upper clad on the waveguide; a current injection electrode disposed on one side of the upper clad and configured to provide a current into the passive waveguide to electrically tune a wavelength of the laser light; an insulation layer disposed on the current injection electrode; and a heater electrode disposed on the insulation layer and configured to heat the upper clad, the passive waveguide, and the lower clad to thermally tune the wavelength of the laser light. Here the gratings, the current injection electrode, and the heater electrode may vertically overlap each other.

In an embodiment, the lower electrode may be disposed under the other side of the lower clad.

In an embodiment, the distributed Bragg reflector tunable laser diode further includes a contact electrode disposed between the upper clad and the current injection electrode and aligned with the gratings, the current injection electrode, and the heater electrode.

In an embodiment, the wavelength of the laser light may be reduced by the current and increased by heating the passive waveguide.

BRIEF DESCRIPTION OF THE FIGURES

The accompanying drawings are included to provide a further understanding of the inventive concept, and are incorporated in and constitute a part of this specification. The drawings illustrate exemplary embodiments of the inventive concept and, together with the description, serve to explain principles of the inventive concept. In the drawings:

FIG. **1** is a plan view showing an example of a distributed Bragg reflector tunable laser diode according to an embodiment of the inventive concept.

FIG. **2** is a cross-sectional view taken along line I-I' of FIG. **1**.

FIG. **3** is a cross-sectional view taken along line II-II' of FIG. **1**.

FIGS. **4** and **5** are cross-sectional views taken along lines of and IV-IV'.

FIG. **6** is a cross-sectional view taken along line V-V' of FIG. **1**.

FIGS. **7** to **10** are plan views showing examples of a heater electrode and a third pad of FIG. **1**.

FIG. **11** is a graph showing a change in wavelength of a laser light of FIG. **1**.

FIG. **12** is a plan view showing an example of a distributed Bragg reflector tunable laser diode according to an embodiment of the inventive concept.

FIG. **13** is a cross-sectional view taken along line VI-VI' of FIG. **12**.

DETAILED DESCRIPTION

Hereinafter, specific embodiments will be described in detail with reference to the accompanying drawings. Advantages and features of the present invention, and methods for achieving the same will be cleared with reference to exemplary embodiments described later in detail together with the accompanying drawings. The inventive concept may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the inventive concept to those skilled in the art. The present disclosure is defined by only scopes of the claims. Throughout this specification, like numerals refer to like elements.

The terms and words used in the following description and claims are to describe embodiments but are not limited the inventive concept. As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising" used herein specify the presence of stated components, operations and/or elements but do not preclude the presence or addition of one or more other components, operations and/or elements. In addition, a solder, blocks, powders, a spacer, and a magnetic field may be understood as mainly used meanings. In addition, as just exemplary embodiments, reference numerals shown according to an order of description are not limited to the order.

FIG. **1** is a plan view showing an example of a distributed Bragg reflector tunable laser diode **10** according to an embodiment of the inventive concept. FIG. **2** is a cross-sectional view taken along line I-I' of FIG. **1**.

Referring to FIG. **1**, the distributed Bragg reflector tunable laser diode **10** of an embodiment of the inventive concept may be a wavelength tunable laser. For example, the distributed Bragg reflector tunable laser diode **10** may be monolithically integrated in an InP substrate **100**. The distributed Bragg reflector tunable laser diode **10** may resonate single mode laser light **102**. According to an example, the substrate **100** of the distributed Bragg reflector tunable laser diode **10** may include a gain section **200** and a distributed reflector section **300**. The gain section **200** may oscillate the laser light **102** by source power. On the contrary, the gain section **200** may generate an optical signal of the laser light **102** according to a current signal of the source power. The distributed reflector section **300** may thermally and/or electrically change a refractive index of the InP substrate to tune the wavelength of the laser light **102**. The gain section **200** and the distributed reflector section **300** may be continuously connected. Hereinafter, for convenience of explanation, the gain section **200** and the distributed reflector section **300** of the substrate **100** will be separately described.

Referring to FIGS. **1** and **2**, the gain section **200** may generate and amplify the laser light **102**. According to an embodiment, the gain section **200** may include a first lower electrode **210**, a first lower clad **220**, an active waveguide **230**, a first upper clad **240**, a first Ohmic contact layer **250**, a first upper electrode **260**, and a first insulation layer **270**.

The first lower electrode **210** may be disposed on a bottom of the gain section **200**. For example, the first lower electrode **210** may include a metal of gold, silver, aluminum, tungsten, molybdenum, manganese, indium, or lead. The first lower electrode **210** may be grounded.

The first lower clad **220** may be disposed on the first lower electrode **210**. For example, the first lower clad **220** may include n-type InP.

The active waveguide **230** may be disposed on the first lower clad **220**. The active waveguide **230** may extend in a first direction. For example, the active waveguide **230** may extend in an x direction. The active waveguide **230** may have a higher refractive index than the first lower clad **220**. According to an example, the active waveguide **230** may include intrinsic InGaAsP or InGaAs. The active waveguide **230** may oscillate the laser light **102**. The active waveguide **230** may have a multiple quantum well (MQW) structure. In addition, the active waveguide **230** may have a gain medium (not shown). The gain medium may include InGaAs or InGaAsP.

FIG. **3** is a cross-sectional view taken along on line II-II' of FIG. **1**.

Referring to FIG. **3**, a first current blocking layer **232** may be disposed at both sides of the active waveguide **230**. The first current blocking layer **232** may concentrate a source current between the first lower electrode **210** and the first upper electrode **260** to the active waveguide **230**. The first current blocking layer **232** may include a compound semiconductor different from that of the active waveguide **230**.

Referring to FIGS. **1** to **3**, the first upper clad **240** may be disposed on the active waveguide **230** and the current blocking layer **232**. The first upper clad **240** may have a lower refractive index than the active waveguide **230**. The first upper clad **240** may include p-type InP.

The first Ohmic contact layer **250** may be disposed on the first upper clad **240**. The first Ohmic contact layer **250** may remove and/or minimize a contact resistance between the first upper clad **240** and the first upper electrode **260**. For example, the first Ohmic contact layer **250** may include p-type InGaAs. The Ohmic contact layer **250** and the first upper electrode **260** may have a Schottky junction. The Ohmic contact layer **250** may be provided to have an Ohmic junction with the first upper electrode **260** through a rapid-thermal annealing (RTA) process.

The first upper electrode **260** may be disposed on the first Ohmic contact layer **250**. The first upper electrode **260** may be connected to a first pad **262**. The first pad **262** may be disposed on a first column **264** and the first insulation layer **270**. An isolation layer **110**, the first column **264** and the first insulation layer **270** may be disposed between the first pad **262** and the first lower clad **220**. The isolation layer **110**, the first column **264** and the first insulation layer **270** may insulate the first pad **262** from the first lower clad **220**. The isolation layer **110** may insulate the first pad **262** from the first upper clad **240** and the first Ohmic contact layer **250**. For example, the first column **264** may include benzocyclobutene or polyimide. The first insulation layer **270** may include silicon oxide ($SiO2$) or silicon nitride SiNx.

When source power is provided between the first upper electrode **260** and the first lower electrode **210**, the oscillating light of the laser light **102** may be generated in the active waveguide **230**. When a data signal is embedded in the source power, the laser light **102** may be modulated to an optical signal. For example the optical signal may be modulated in a high speed at about 1 GHz or higher.

Referring to FIGS. **1** and **2** again, the distributed reflector section **300** may resonate with the oscillating laser light **102**. According to an example, the distributed reflector section **300** may include a second lower clad **320**, gratings **322**, a passive waveguide **330**, a second upper clad **340**, a second Ohmic contact layer **350**, a first current injection electrode **360**, a second insulation layer **370**, and a heater electrode **380**.

The second lower clad **320** may be connected to the first lower clad **220**. For example, the second lower clad **320** may include n-type InP. The first and second lower clads **220** and **320** may be one successive layer.

The gratings **322** may be disposed in the second lower clad **320**. Unlike this, the gratings **322** may be disposed in the second upper clad **340** on the passive waveguide **330**. The top surface of the gratings **322** may be lower than that of the second lower clad **320**. The gratings **322** may be separately disposed in the x direction. The gratings **322** may reflect the laser light **102**. The active waveguide **230**, the passive waveguide **330** and the gratings **322** may resonate with the laser light **102**. The gratings **322** may be formed of a material different from that of the second lower clad **320**. For example, the gratings **322** may include n-InGaAsP. The gratings **322** may satisfy a Bragg condition $m\lambda=2n_{eq}\Lambda$, where m is an order of diffraction of 1, λ is a wavelength of a light, n_{eq} is an effective refractive index of a guiding layer, and Λ is a period of a refractive grating. For example, the wavelength λ of the laser light **102** may be determined depending on the passive waveguide **330** and/or an effective refractive index n_{eq} of the second lower clad **320**.

The passive waveguide **330** may be connected to the active waveguide **230**. The passive waveguide **330** may extend in the x direction. The passive waveguide **330** may be disposed on the second lower clad **320**. The passive waveguide **330** may be provided on the gratings **322**. The passive waveguide **330** may include intrinsic InGaAsP or InGaAs. The laser light **102** may travel along the passive waveguide **330**.

FIGS. **4** and **5** are cross-sectional views taken along lines of and IV-IV'.

Referring to FIGS. **4** and **5**, the second blocking layer **332** may be disposed between both side walls of the passive waveguide **330**. The second current blocking layer **332** may be connected to the first current blocking layer **232** of FIG. **3**. The first and second current blocking layers **232** and **332** may be one successive layer. The second current blocking layer **332** may concentrate, into the passive waveguide **330**, a wavelength tuning current between the first current injection electrode **360** and the first lower electrode **210**. The second current blocking layer **332** may include a compound semiconductor different from that of the passive waveguide **330**.

According to an example, the second lower electrode **310** may be disposed under the second lower clad **320**. The second lower electrode **310** may be grounded. The second current blocking layer **332** may concentrate, into the passive waveguide **330**, a wavelength tuning current between the first current injection electrode **360** and the second lower electrode **310**. Unlike this, the second lower electrode **310** may be omitted and when there is not the second lower electrode **310**, the wavelength tuning current may flow between the first current injection electrode **360** and the first lower electrode **210**.

The second upper clad **340** may be connected to the first upper clad **240**. The first and second lower clads **240** and **320** may be one successive layer. The second upper clad **340** may be disposed on the passive waveguide **330** and the second current blocking layer **332**. The second upper clad **340** may be disposed on the first upper clad **240**. The second upper clad **340** may include p-type InP.

The second Ohmic contact layer **350** may be disposed on the second upper clad **340**. The second Ohmic contact layer **350** may remove and/or minimize contact resistance between the second upper clad **340** and the first current injection electrode **360**.

The first current injection electrode **360** may be disposed on the second Ohmic contact layer **350**. For example, the first current injection electrode **360** may overlap the gratings **322**.

FIG. **6** is a cross-sectional view taken along line V-V' of FIG. **1**.

Referring to FIG. **6**, the second pad **362** may be connected onto the first current injection electrode **360**. The second pad **362** may be disposed on the isolation layer **110**, a second column **384** and the second insulation layer **370**. The isolation layer **110**, the second column **384** and the second insulation layer **370** may be disposed between the second pad **362** and the second lower clad **320**. The isolation layer **110**, the second column **384** and the second insulation layer **370** may insulate the second pad **362** from the second lower clad **320**. The isolation layer **110** may insulate the second pad **362** from the second upper clad **340** and the second Ohmic contact layer **350**. The second column **384** may include benzocyclobutene, polyimide, or an insulating material.

The second insulating layer **370** may be disposed on the first current injection electrode **360**. Unlike this, the second insulation layer **370** may be disposed on the second column **384**. The second insulation layer **370** may be substantially connected to the first insulation layer **270**. The second insulation layer **370** may include a dielectric or polyimide.

When the wavelength tuning current is provided through the second pad **362**, the second lower clad **320**, the gratings **322**, the passive waveguide **330**, and/or the second upper clad **340** may have changes in refractive index. The wavelength of the laser light **102** may be tuned by a refractive index change of the distributed reflector section **300**. For example, when the wavelength tuning current is injected to the passive waveguide **330**, the effective refractive index of the passive waveguide **330** may be reduced. The Bragg condition may be determined according to the effective refractive index of the passive waveguide **330**. Accordingly, the wavelength of the laser light **102** may be tuned.

Referring to FIGS. **2**, **4** and **5** again, the heater electrode **380** may be disposed on the second insulation layer **370**. According to an example, the heater electrode **380** may vertically overlap the first current injection electrode **360** and the gratings **322**.

FIGS. **7** to **10** show examples of the heater electrode **380** and third pads **382** of FIG. **1**.

Referring to FIGS. **1** and **7** to **10**, the heater electrode **380** may connect the third pads **382**. For example, the heater electrode **380** may have a straight line shape, an uneven shape, a comb shape or a mesh shape.

Referring to FIGS. **4**, **5** and **7** to **10**, the third pads **382** may be connected to the heater electrode **380**. The third pads

382 may be disposed on both edges of the heater electrode **380**. Each of the third pads **382** may have various shapes.

Referring to FIGS. **4** and **5**, the third pads **382** may be disposed on third columns **386** and the second insulation layer **370**. The isolation layer **110**, the third columns **386** and the second insulation layer **370** may insulate the third pads **382** from the second lower clad **320**. The isolation layer **110** and the second insulation layer **370** may insulate the third pads **382** from the second upper clad **340** and the second Ohmic contact layer **350**. For example, the third columns **386** may include benzocyclobutene.

Referring to FIGS. **1**, **2**, **4** and **5**, when heating power is supplied into the heater electrode **380** through the third pads **382**, the heater electrode **380** may gradually heat the second upper clad **340**, the passive waveguide **330** and the second lower clad **320**.

Refractive indexes of the heated second upper clad **340**, passive waveguide **330**, and second lower clad **320** may be changed. For example, the wavelength of the laser light **102** may be tuned mainly by a refractive index change of the passive waveguide **330**.

FIG. **11** shows a wavelength change of the laser light **102** of FIG. **1**.

Referring to FIG. **11**, the wavelength of the laser light **102** may be changed according to the wavelength tuning current and heating current.

According to an example, the wavelength of the laser light **102** may be shortened by the wavelength tuning current. For example, the wavelength of the laser light **102** may be reduced from about 1557 nm to about 1550 nm in a current range of tens of mA. The wavelength of the laser light **102** may be reduced by about 7 nm. Power peaks between about 1557 nm and about 1550 nm in FIG. **11** may correspond to changes in wavelength of the laser light **102**.

According to an example, the wavelength of the laser light **102** may be lengthened by the heating current. For example, the wavelength of the laser light **102** may be increased from about 1557 nm to about 1575 nm in a current range of about 100 mA. The wavelength of the laser light **102** may be increased by about 19 nm. Power peaks between about 1557 nm and about 1575 nm in FIG. **11** may correspond to changes in wavelength range. The above numerical values have been presented to assist understanding of the inventive concept, but are not limited thereto and may be changed in various ways.

The peaks of the laser light **102** of FIG. **11** may exist between about 1557 nm and about 1575 nm.

FIG. **12** shows an example of a distributed Bragg reflector tunable laser diode **10***a* according to an embodiment of the inventive concept. FIG. **13** is a cross-sectional view taken along line VI-VI' of FIG. **12**.

Referring to FIGS. **12** and **13**, the substrate **100***a* of the distributed Bragg reflector tunable laser diode **10***a* may include a phase section **400** between a gain section **200** and a distributed reflector section **300**. The gain section **200** and the distributed reflector section **300** may be configured identically to those of FIGS. **1** and **2**.

The phase section **400** may tune the phase of the laser light **102**. According to an example, the phase section **400** may include a third Ohmic contact layer **450** and a second current injection electrode **460** on the passive waveguide **330** and the second upper clad **340**. The second current injection electrode **460** may be connected to a fourth pad **462**.

The foregoing description is about detailed examples for practicing the inventive concept. The embodiment of the inventive concept disclosure includes not only the above-described embodiments but also simply changed or easily modified embodiments. In addition, the inventive concept may also include technologies obtained by easily modifying and practicing the above-described embodiments.

As described above, a distributed Bragg reflector tunable laser diode according to an embodiment of the inventive concept may include a distributed reflector section having gratings, a current injection electrode and a heater electrode. The gratings, the current injection electrode, and the heater electrode may vertically overlap each other. The current injection electrode may electrically tune a wavelength of laser light by providing a current into a waveguide of the distributed Bragg reflector tunable laser diode. The heater electrode may thermally tune the wavelength of the laser light by heating the waveguide. The wavelength of the laser light may be efficiently tunable.

Although the exemplary embodiments of the present invention have been described, it is understood that the present invention should not be limited to these exemplary embodiments but various changes and modifications can be made by one ordinary skilled in the art within the spirit and scope of the present invention as hereinafter claimed.

What is claimed is:

1. A distributed Bragg reflector tunable laser diode comprising:

a substrate including a gain section which has an active waveguide to get gain of a laser light and a distributed reflector section which has a passive waveguide connected to the active waveguide,

wherein the distributed reflector section comprises:

gratings disposed on or under the passive waveguide;

a current injection electrode disposed on the passive waveguide and configured to provide a current into the passive waveguide to electrically tune a wavelength of the laser light; and

a heater electrode disposed on the current injection electrode and configured to heat the passive waveguide to thermally tune the wavelength of the laser light,

wherein the gratings, the current injection electrode, and the heater electrode vertically overlap each other.

2. The distributed Bragg reflector tunable laser diode of claim **1**, wherein the gain section further comprises:

a first lower electrode under the active waveguide;

a first lower clad between the first lower electrode and the active waveguide;

a first upper clad disposed on the active waveguide; and

a first upper electrode disposed on the first upper clad.

3. The distributed Bragg reflector tunable laser diode of claim **2**, wherein the distributed reflector section further comprises:

a second lower clad connected to the first lower clad and surrounding the gratings; and

a second upper clad connected to the first upper clad and disposed on the passive waveguide.

4. The distributed Bragg reflector tunable laser diode of claim **3**, wherein the distributed reflector section further comprises a second lower electrode connected to the first lower electrode and disposed under the second lower clad.

5. The distributed Bragg reflector tunable laser diode of claim **3**, wherein the gain section further comprises a first contact electrode between the first upper clad and the first upper electrode,

wherein the distributed reflector section further comprises a second contact electrode between the second upper clad and the current injection electrode.

6. The distributed Bragg reflector tunable laser diode of claim **5**, wherein the distributed reflector section further comprises an insulation layer between the current injection electrode and the heater electrode.

7. The distributed Bragg reflector tunable laser diode of claim **6**, wherein the insulation layer is disposed between the first and second contact electrodes.

8. The distributed Bragg reflector tunable laser diode of claim **7**, wherein the distributed reflector section further comprises:

first and second pads connected to the current injection electrode and the heater electrode; and

first and second columns disposed between the first and second pads and the first and second lower clads.

9. The distributed Bragg reflector tunable laser diode of claim **8**, wherein the first and second columns comprise benzocyclobutene.

10. The distributed Bragg reflector tunable laser diode of claim **1**, wherein the substrate further comprises a phase section between the gain section and the distributed reflector section.

11. The distributed Bragg reflector tunable laser diode of claim **1**, wherein the heater electrode has a straight line shape, an uneven shape, a comb shape, or a mesh shape.

12. The distributed Bragg reflector tunable laser diode of claim **1**, wherein the substrate comprises InP.

13. The distributed Bragg reflector tunable laser diode of claim **1**, wherein the current reduces the wavelength of the laser light.

14. The distributed Bragg reflector tunable laser diode of claim **13**, wherein the wavelength of the laser light is increased by heating the passive waveguide.

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